Continuous measurements of ammonia, sulfate and nitrate in Pittsburgh: Implications for $PM_{2.5}$ control strategies

Beth Wittig, Andrey Khlystov, Satoshi Takahama, Cliff Davidson, Allen Robinson, Susanne Hering, and Spyros Pandis

Department of Chemical Engineering, Carnegie Mellon University, Pittsburgh

When SO_2 emissions are reduced, their major aerosol product, sulfate, also decreases. Since aerosol sulfate is usually in the form of ammonium sulfate, reducing the amount of sulfate results in more free ammonium, which returns to the gas phase as ammonia. The additional ammonia can react with available nitric acid vapor to produce ammonium nitrate aerosol. Thus sulfate can be replaced with nitrate as sulfur emissions decrease, and airborne $PM_{2.5}$ mass may not decrease proportionally with SO_2 emission reductions. In extreme cases (low temperature, high relative humidity, high ammonia concentrations), SO_2 emission reductions might even increase $PM_{2.5}$ concentrations. This is because two ammonium ions are released for each sulfate ion, resulting in as many as two ammonium nitrate molecules.

Quantification of the sulfate/nitrate/ammonium interactions requires high temporal resolution measurements of all the species involved in both the gas and particulate phases. During the Pittsburgh Air Quality Study (PAQS) the concentrations of $PM_{2.5}$ nitrate, sulfate, ammonium and gas-phase nitric acid and ammonia were continuously measured during the summer, fall, and winter of 2001. These measurements, combined with numerical models describing the partitioning and removal of chemical components, are used to investigate the response of the $PM_{2.5}$ concentrations to changes in the NO_x and SO_2 emissions.